

A DISCUSSION OF THE RESULTS
of the
TESTS OF THE ALPHA AND UNITED STATES
CREAM SEPARATORS.

by

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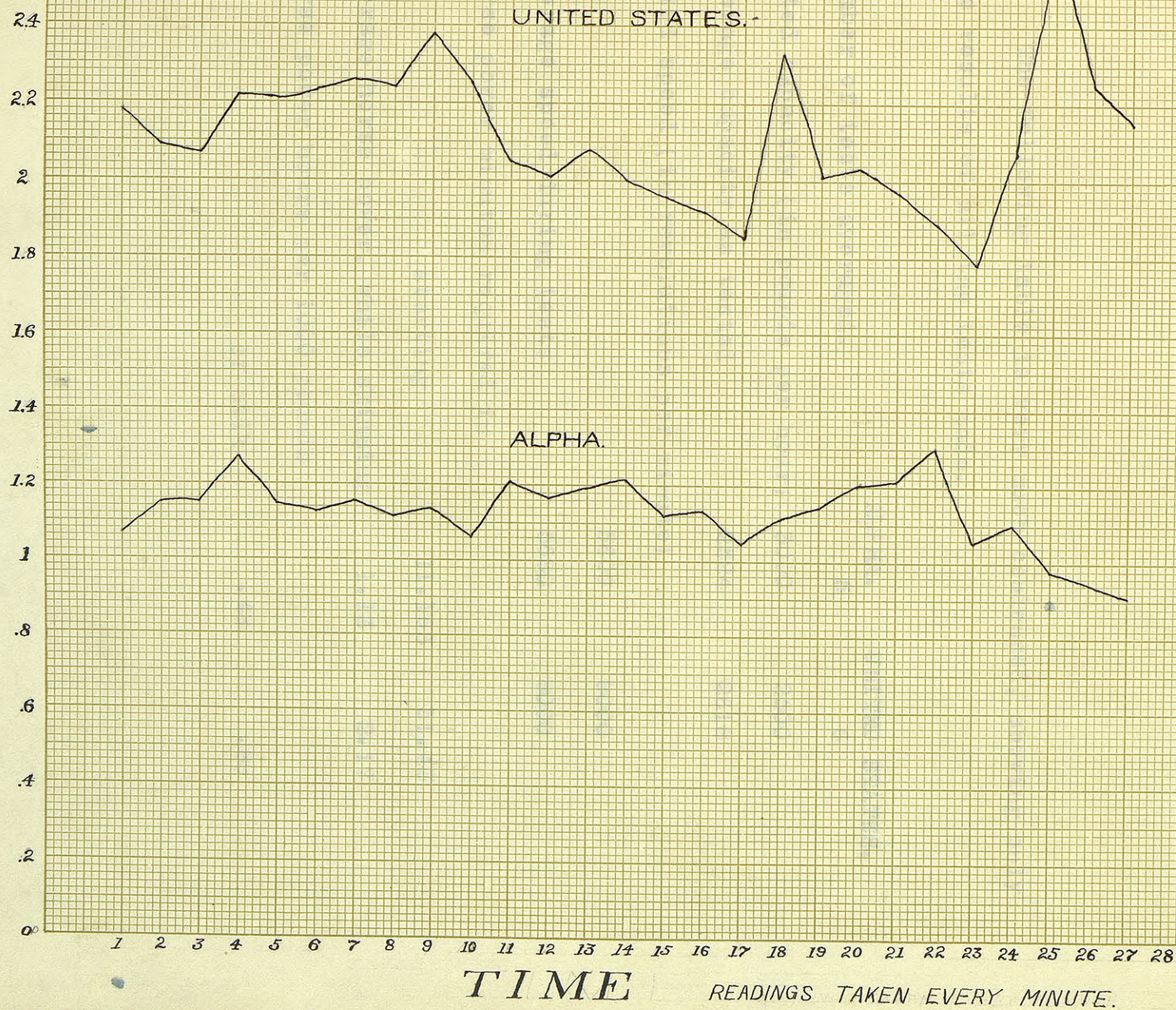
OUTLINE.

1. Summary of Mr. Waldraven's tables with graphical sketch.
2. Two reasons why the horse power required by the
United States separator should be greater than that
required by the Alpha.
 - (a) High speed of the United States bowl
requiring work to get up speed.
 - (b) Discharge orifices farther from the
center in the United States than in
the Alpha.
3. A partial investigation into the meaning of these
results, and what they indicate.

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UNITED STATES CREAM SEPARATORS.

In the thesis, submitted by Mr. L. W. Waldraven, exhaustive tables are presented of the comparative test of the United States, No. 1, belt-driven cream separator, and the Alpha DeLaval, belt-driven, No. 1. Mr. Waldraven's thesis also contains notes and full explanations of how the experiments were conducted, power measured and the apparatus used. But it is considered not superfluous to repeat that the greatest care was taken to have the conditions the same for the two machines, even to the same number of drops of oil used, per minute, in each case.

In the following graphical representation of the power required by the two separators, the averages of all the tests made on each separator are the results plotted.



The following table is very much condensed, showing only average results of all the tests made.

	ALPHA.	UNITED STATES.
Number of tests averaged.	5	6
Rated capacity (in pounds per hour)	3000	2500
Average capacity as tested	2524	2618
Rated speed (in revolutions per minute)		
	5600	8000
Average speed during tests	5680	8000
Horse power minutes required in		
starting	11.163	31.43
Average horse power, while skimming	1.13	2.17
Horse power hours per 1000 pounds		
of milk	.48	.89

The total weight of the United States bowl and revolving parts is 97 3/4 pounds, and its greatest diameter is 13.5 inches. Its average speed during all of the tests was 8000 revolutions per minute. The total weight of the revolving parts of the Alpha separator is 107 pounds, but its greatest diameter is only 11 5/8 inches, and its average speed during tests, only 5680 revolutions per minute.

Now, altho the Alpha bowl weighs about 10 pounds more than the United States bowl, its outer circumference is travelling at a rate of

$$\frac{.969 \times \pi \times 5600}{60} = 284 \text{ ft. per second, or } 3.23 \text{ mi. per minute.}$$

While the outer circumference of the United States bowl travels at a rate of

$$\frac{1.125 \times \pi \times 8000}{60} = 471 \text{ ft. per second or } 5.35 \text{ mi. per minute.}$$

The radius of gyration of the United States bowl corresponds more nearly with 13.5 inches than the radius of gyration of the Alpha bowl does with 11 5/8 inches. Or, in other words, in the case of the Alpha, the weight is more evenly distributed thruout the entire bowl, and not merely in the outer shell as is the case with the United States. Remembering then, that kinetic energy varies with the square of the velocity we readily see why it requires nearly three times as much power to bring the United States up to normal

speed, as is necessary for the Alpha.

The United States machine was driven by a flat belt from the intermediate to the separator, while the Alpha was driven by a rope belt. There exists considerable difference of opinion as to the relative efficiencies of the flat and rope belts; due, no doubt, to varying results under different conditions. The power transmitted by a belt is measured by the difference of pull between the tight and loose sides. The most efficient therefore is the one which will give a required difference of pull, at a given speed, with the least total pull; or, in other words, the belt whose coefficient of friction with the pulley is greatest. Tight belts are ruinous to economy. This is shown by repeated instances in Mr. Waldraven's tables, where the belt was tightened and the horse power required nearly doubled, while the speed scarcely increased at all.

During these tests care was taken to keep the belts on both separators just tight enough to prevent slipping. And, since we have no comparative data on this subject which would apply to these cases, we will assume during the remainder of the discussion that the belts were equally efficient.

When we consider the high velocity which the separator bowl has, it is at once apparent that by locating the discharge orifices farther from the axis of the bowl, the milk would acquire a greater momentum on leaving the separator, thus absorbing more work.

The discharge orifices of the United States bowl are two inches from the axis. Then assuming average conditions, we will attempt to determine the energy carried away by the skim milk, due to its tangential velocity alone. Tangential momentum is equal to mv , where v is velocity in feet per second, and m is the mass of milk passing out in one second. This quantity multiplied by v will give the foot pounds of work per second, and this divided by 550, will give the horse power per minute. Then

$$\frac{2618}{3600 \times 32.2} \left(\frac{\pi \times 8000}{3 \times 60} \right)^2 = 1.8 \text{ H.P. per minute.}$$

The distances of the discharge orifices of the Alpha bowl from the axis are $1 \frac{11}{16}$ inches; then the work lost in discharging its skim milk, assuming average conditions as before, is:

$$\frac{2524}{3600 \times 32.2} \left(\frac{.281 \pi \times 5680}{60} \right)^2 = .276 \text{ H.P. per minute.}$$

This is at least a very surprising result. The ratio of the work actually required to operate the Alpha to the work required to operate the United States is as 1 to 1.92. While the ratio of the work theoretically required, basing our calculations on the tangential velocity of the skim milk is as 1 to 6.5. This seems to indicate that if the discharge orifices of the United States machine could be brought near enough to the axis of the bowl so that the milk would leave with the same tangential velocity as it does with the Alpha

DeLaval, the United States would be much the more economical of the two.

The efficiency of a machine is the ratio of the work done by it to the work required to run it. Assuming that the work actually required to disassociate the cream from the milk is the same in both separators, neither will suffer in a comparison from which this factor is dropped; then, neglecting the momentum of the cream, the efficiency of the Alpha separator is

$$\frac{.276}{1.13} = .244 .$$

While the efficiency of the United States machine is

$$\frac{1.8}{2.17} = .83 \text{ nearly.}$$

It is plain that, while the greater part of the work required to run the United States machine is lost with the discharged skim-milk, the most of the work required to operate the Alpha DeLaval must be consumed in some other way.

In the Alpha bowl, are 14 discs, 7 1/4 inches in diameter, exposing 28 surfaces for the milk to spread over moving at a high rate of speed. Fluid friction depends on the nature of the fluid and varies directly with the surface exposed, and with the square of the velocity. The United States bowl has probably no more than one-tenth or one-twelfth as much surface exposed to fluid friction as the Alpha, and the velocity of the milk flowing over it is probably about the same. This is possibly one way in which the great bulk of the work of the Alpha is consumed. At first thought, this seems to condemn

the discs, a feature of the Alpha machine for which its manufacturers claim a special point of excellence and superiority over others.

But the fact remains that the Alpha separator required only a little more than one-half as much horse-power as the United States to separate the same quantity of milk, and do it just as well. If the discs were discarded, the speed would have to be increased in order to effect complete separation; and this would entail a greater loss from the tangential momentum of the milk, the inertia of the bowl in starting, and other losses due to high speed. With the United States bowl, as it is, the speed cannot be decreased, because the separation would not be complete, and it may be that if the discharge orifices were nearer the axis, the milk would not discharge rapidly enough. If this is the case, then it would seem that the United States type of bowl has reached its limit of efficiency.